APPLICATION FOR PATENT

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Title: SUTURING INSTRUMENT AND METHOD

This is a continuation-in-part of U.S. Patent Application No. 09/722,712, filed November 28, 2000, the specification of which is incorporated herein by reference.

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to suturing instruments useful in surgery, and also to a method of applying a suture to tissue during surgery.

Many surgical procedures are presently being performed via an endoscope in order to minimize the size of the incisions and the trauma to the patient. In such procedures, the surgical instrument is generally introduced through a cannula or passageway in the endoscope while the surgeon views the surgical site through another passageway in the endoscope. A number of forceps-type suturing instruments have been designed for introduction through a cannula used in endoscopic procedures . One such forceps-type suturing instrument is disclosed in US Patents 5,730,747 and 6,051,006. The known suturing instruments of this type, however, are generally of relatively complicated construction and/or are useful only with respect to needled sutures.

OBJECTS AND SUMMARY OF THE INVENTION

An object of the present invention is to provide a suturing instrument of relatively simple construction and which can be used with unneedled sutures, i.e., suture threads *per se*, i.e., without a puncturer being attached to the suture.

Another object of the invention is to provide a suturing instrument

particularly useful as a forceps type instrument for introduction through a cannula used in endoscopic procedures. A further object of the invention is to provide a novel method of applying a suture to tissue.

According to one aspect of the present invention, there is provided a suturing instrument comprising: a jaw formed with an opening therethrough; a puncturer pivotally mounted from an open position on one side of the jaw to a closed position through the opening to the opposite side of the jaw, the puncturer being constructed to receive a suture in the open position of the puncturer and to move a portion of the suture through the jaw opening to the opposite side of the jaw when actuated to the closed position of the puncturer; and a crochet head for engaging the portion of the suture at the opposite side of the jaw opening and for clamping the suture to the jaw thereby permitting the puncturer to return to its open position while disengaged from the suture.

According to another aspect of the present invention, there is provided a method of applying a suture to tissue, comprising: pivotally mounting a puncturer with respect to a jaw having an opening therethrough such that the puncturer is pivotal from an open position on one side of the jaw through the opening in the jaw to a closed position on the opposite side of the jaw; applying a suture to the puncturer when the puncturer is in its open position on one side of the jaw; locating the jaw on one side and the pivotal puncturer on the opposite side, of the tissue to be sutured; pivoting the puncturer towards the jaw to pierce the tissue and to pass the puncturer therethrough and through the opening in the jaw to the closed position of the puncturer on the opposite side of the jaw, and thereby to bring a portion of the suture with the puncturer to the opposite side of the jaw; clamping to the jaw the portion of the suture at the opposite side of the jaw; and pivoting the puncturer back to its open position while the suture is clamped to the jaw.

According to a further aspect of the present invention, there is provided a tissue suturing instrument comprising a tissue grasping mechanism designed

and configured for grasping a tissue and for positioning a suture on a first side of tissue; and a crochet head designed and configured for piercing through the tissue from a second side thereof and engaging the suture, thereby enabling drawing the suture through the tissue.

According to features in a described embodiment of the invention, the crochet head is slidably mounted at the opposite side of the jaw and is movable through a forward stoke from a retracted position at the proximal end of the jaw to an extended position at the distal end of the jaw, and through a return stroke back to the retracted position. The crochet head has a shaped surface effective to engage the portion of the suture at the opposite side of the jaw during the forward stroke of the crochet head, and to clamp same to the jaw during the return stroke of the crochet head.

According to further features in the described embodiment, the jaw is part of a frame assembly including a proximal section formed with a first handle, and a distal section carrying the jaw; and the puncturer is part of a puncturer assembly including a proximal section formed with a second handle pivotally mounted with respect to the first handle, a distal section including the pivotally mounted puncturer, and a coupling between the second handle and puncturer for pivoting the puncturer from the open position to the closed position upon pivoting the second handle with respect to the first handle. Similarly, the crochet head is part of a crochet head assembly including a proximal section formed with a third handle pivotally mounted with respect to the first handle, a distal section carrying the crochet head, and a coupling for moving the crochet head through its forward and return strokes by the pivoting of the third handle with respect to the first handle.

According to further features in the described embodiment, the instrument comprises a frame assembly including a proximal section formed with a first handle and a distal section carrying the tissue grasping mechanism and the crochet head, the sections connected by an elongated shank.

According to further features in the described embodiment, the first handle is disposed substantially perpendicular to the elongated shank.

According to further features in the described embodiment, the tissue grasping mechanism comprises at least two grasping members including a static member disposed rigidly upon the elongated shank and a movable member pivotally movable relative to the static member.

According to further features in the described embodiment, the movable member is pivotally mounted to the static member.

According to further features in the described embodiment, the static member is formed with a face facing the movable member having a ribbed surface for firmly grasping the tissue.

According to further features in the described embodiment, the static member is formed with a guide member disposed thereon for guiding the crochet head.

According to further features in the described embodiment, the movable member is for carrying the suture, whereas a distal end of the movable member is formed with an opening therethrough alignable with the guide member for guiding the crochet head to engage the suture when the suture is positioned on the first side of the tissue.

According to further features in the described embodiment, the tissue grasping mechanism is part of a tissue grasping assembly including a proximal section formed with a second handle pivotally mounted relative to the first handle, a distal section carrying the static member and the movable member, and a coupling between the second handle and the movable member for pivoting the movable member upon pivoting the second handle.

According to further features in the described embodiment, the coupling includes a rod extending through the elongated shank of the frame assembly.

According to further features in the described embodiment, the crochet head is part of a crochet head assembly including a proximal section formed

with a third handle pivotally mounted relative to the first handle, a distal section carrying the crochet head, and a coupling between the third handle and the crochet head for moving the crochet head upon pivoting the third handle.

According to further features in the described embodiment, the coupling includes a slide slidable with respect to the elongated shank of the frame assembly, the slide being aligned with the guide member.

According to further features in the described embodiment, the crochet head is slidably mounted in proximity to the tissue grasping mechanism and is movable through a forward stroke from a retracted position at a proximal end of the tissue grasping mechanism to an extended position beyond a distal end of the tissue grasping mechanism, and through a return stroke back to the retracted position; the crochet head having a point for piercing the tissue during the forward stroke, a shaped surface for engaging the suture, and a hook formation for drawing the suture through the tissue during the return stroke.

According to further features in the described embodiment, the third handle is spring-biased to the retracted position.

As will be described more particularly below, the foregoing features enable suturing instruments to be constructed with a relatively few simple parts and to be used with unneedled sutures.

Further features and advantages of the invention will be apparent from the description below.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in the cause of providing what is believed to be the most useful and readily understood

description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

In the drawings:

FIG. 1 is a side view illustrating a preferred embodiment of a suturing instrument constructed in accordance with the present invention;

FIG. 2 is an enlarged bottom view of the distal end of the suturing instrument of Figure 1, illustrating the puncturer in its open position for receiving a suture;

FIG. 3 is an enlarged side view of the distal end of the suturing instrument of Figure 1 with the crochet head in its extended position;

FIG. 4 is a perspective view of the distal end of an alternative embodiment of a suturing instrument constructed in accordance with the present invention, illustrating the grasping mechanism in its closed position;

FIG. 5 is a perspective view of the distal end of the suturing instrument of Figure 4 illustrating the grasping mechanism in its open position; and

FIG. 6 is and end view of the movable grasping member of the suturing instrument of Figure 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is of suturing devices and methods which can be used to efficiently insert a suture in tissue during surgery. Specifically, the present invention can be used in minimally invasive, endoscope, laparoscope or arthroscope assisted surgeries.

The principles and operation of a device and method according to the present invention may be better understood with reference to the drawings and accompanying descriptions.

Before explaining the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following descriptions or illustrated in the drawings. The invention is capable of other embodiments or of being practiced or carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

Figure 1, illustrates one configuration of a suturing device/instrument according to the present invention.

The suturing instrument illustrated in Figure 1 is of the forceps type particularly useful by applying it through a cannula used in endoscopic procedures in order to suture tissue at the surgical site.

This configuration of the suturing instrument is composed of three main assemblies:

(1) a frame assembly, generally designated **2**, including a first handle **2** at one end (hereinafter called the proximal end), fixed substantially perpendicularly to an elongated shank **21** (Figure 2);

(2) a puncturer assembly, generally designated **3**, including a second handle **30** at the proximal end of the instrument, pivotally mounted to the frame assembly **2** and coupled to a puncturer **31** (Figure 2) pivotally mounted at the distal end of the elongated shank **21**; and

(3) a crochet head assembly, generally designated 4, including a third handle **40** also pivotally mounted to the frame assembly **2** and coupled to a slidable crochet head **41** at the distal end of the elongated shank **21**.

As will be described more particularly below, the suture, shown at **5** in Figure 2, is loaded onto the puncturer **31** when in its open position as illustrated in Figure 2.

With respect to the frame assembly **2**, the proximal end of the elongated shank **21** is fixed within a perpendicular extension **22** at the upper end of

handle **20**. The distal end of the elongated shank **21** carries a fixed jaw **23** formed with a pair of legs **23a**, **23b** parallel to the axis of the elongated shank **21** and spaced from each other to define a space **23c**. As shown particularly in Figure 2, the inner surface of jaw **23** facing the pivotal puncturer 31 is ribbed as shown at **23d** in order to firmly grasp the tissue to be sutured between it and the pivotal puncturer, as will be described below.

The distal end of the elongated shank **21** further includes a U-shaped member **24** serving as a guide for a part of the crochet head assembly **4**, as will be described below. In addition, extension **22** of handle **20** is formed with a slot **25** (Fig. 1) at the proximal end of the elongated shank **21**, for accommodating a coupling element of the crochet head assembly **4** as will also be described below. Further, the upper end of handle **20** of the frame assembly **2** includes an abutment **26** serving as a stop for limiting the pivotal movement of handle **30** of the puncturer assembly **3**.

With respect to the puncturer assembly **3**, handle 30 of that assembly is pivotally mounted at **32** to the upper end of handle **20** of the frame assembly **2**. As shown particularly in Fig 2, puncturer **31** pivotally mounted at the distal end of the elongated shank **21**, is formed with a hole **31a** for receiving the suture **5**, and with a pointed tip **31b** for piercing the tissue clamped between it and the ribbed surface **23d** of the fixed jaw **23**.

Puncturer **31** is pivotally mounted to the distal end of the elongated shank **21** by an arm **33** carrying the puncturer **31** at one end, and pivotally mounted at its opposite end **34** to the elongated shank **21**. Arm **33** is coupled to the upper end of handle **30** of the puncturer assembly **3** by a rod **35** (Fig. 1) passing through, or alongside of, the elongated shank **21**. The arrangement is such that pivoting handle **30** away from handle **20** pivots puncturer **31** to its open position illustrated in Figure 2 for receiving the suture **5**, and pivoting handle **30** towards handle **20** moves puncturer **31** through the opening **23c** in the jaw **23** to pierce the tissue clamped between the puncturer and the jaw, and

to bring the suture **5** to the opposite side of the jaw. Handle **30** is formed on its inner face with an abutment **36** engagable with abutment **26** of handle **20** to limit the latter pivotal movement of handle **30**.

With respect to the crochet head assembly **4**, its handle **40** is pivotally mounted at **42** to the upper end of handle **20** of the frame assembly **2**. Preferably, this pivotal mounting includes a piano spring (not shown) to bias the handle **40** to the position illustrated in Figure 1, which is the retracted position of the crochet head **41**.

The crochet head **41** is carried at the distal end of a slide **43** extending along one side of the elongated shank **21**. The proximal end of slide **43** is coupled by a pin **44** (Fig. 1) to the upper end of handle **40**. Pin **44** is movable within slot **25** in the extension **22** at the upper end of handle **20** to limit the pivotal movements of handle **40** with respect to handle **20**. As will be described below, handle **40** may be pivoted with respect to handle **20** to move slide **43**, and the crochet **41** carried at the distal end of the slide, through forward and return strokes parallel to the longitudinal axis of the elongated shank **21**. The forward and return movements of the slide **43** are guided by the U-shaped member **24** at the distal end of the elongated shank.

The structure of the crochet head **41** is more particularly illustrated in Figure 3. It includes a tapered nose **41a** at one end for engaging the suture **5** during the forward movement of the crochet head, and a hook formation at the opposite end for receiving the suture and for clamping it to the jaw **23** during the return movement of the crochet head. The crochet head is further formed with an axial slot **41c** to accommodate the pointed tip **31b** of the puncturer **31** when the puncturer is pivoted to its closed position and the crochet has been moved to its most forward position.

The illustrated suturing instrument may be used in the following manner.

First, handle **30** is pivoted away from handle **20** so as to pivot the puncturer **31** to its open position as shown in Figure 2, to enable the suture **5** to be loaded thereon by passing the suture through opening **31a** of the puncturer.

Handle **30** may then be pivoted towards handle **20** to move the puncturer **31**, together with the portion of the suture carried thereby, to the closed position of the puncturer, i.e., through opening **23c** of jaw **23**. This enables the distal portion of the instrument to be inserted through the cannula (not shown) of the endoscope. After the distal portion of the instrument has passed through the cannula and is located in the surgical site, handle **30** may be pivoted away from handle **20** to return the puncturer to its open position, as shown in Figure 2, preparatory to its use for suturing tissue. In this condition of the instrument, handle **40** is in the position shown in Figure 1, such that the crochet head **41** actuated by the handle is in its retracted position on the proximal side of jaw **23**.

The surgeon may then manipulate the instrument with the puncturer **31** in its open position to locate the puncturer on one side of the tissue to be sutured, and to locate the jaw **23** on the opposite side of the tissue to be sutured. The surgeon then moves handle **30** towards handle **20**, which thereby, by virtue of the coupling rod **35**, pivots puncturer **31** towards jaw **23** and then through the opening **23c** in the jaw, to thereby pierce the tissue and to bring the portion of suture **5** within the needle hole **31a** to the opposite side of the jaw. While the puncturer is in its closed position, handle **40** is then pivoted clockwise to move the crochet head **41**, coupled to the handle by slide **43**, through a forward stroke parallel to the elongated shank **21** from the proximal side of the jaw **23** to the distal side thereof, and then releases handle **40** to permit its spring bias to return the crochet head through a return stroke back to its initial position at the proximal side of the jaw.

During the movement of the crochet head in the forward stroke, its nose **41a** engages the suture that has been passed through opening **23c** in jaw **23**, and guides the suture to the hook portion **41b** of the crochet head, such that when

the crochet head returns during the return stroke back to its initial position, the hook portion **41b** of the crochet head clamps the suture to the jaw **23**. Handle **30** may then be moved away from handle **20** to pivot the puncturer **31** to its open position, and thereby to release the tissue. The instrument may then be used for applying another suture to another portion of the tissue by repeating the foregoing steps.

Reference is now made to Figures 4-6 which illustrate an alternative embodiment of the suturing instrument of the present invention which is referred to hereinunder as suturing instrument **45**.

Suturing instrument **45** includes a frame assembly (not shown) which is substantially identical to frame assembly **2** shown in Figure 1 and as such includes a first handle at the proximal end, fixed substantially perpendicularly to an elongated shank; a perpendicular extension at the upper end of the first handle which is formed with a slot for accommodating a coupling element; a second handle pivotally mounted to the upper end of the first handle; a coupling element for coupling the second handle to the tissue grasping elements; a first abutment at the upper end of the first handle serving as a stop for limiting the pivotal movement of the second handle; a second abutment at the upper end of the second handle engagable with the first abutment; a third handle pivotally mounted to the upper end of the first handle, preferably including a piano spring to bias the third handle to the position illustrated in Figure 1; and a pin movable within a slot which couples a coupling slide to the upper end of the third handle. These components of suturing instrument **45** function similarly to those described hereinabove with respect to Figure 1, and as such are numerically referenced hereinunder, in parentheses, with numbers used to identify similar components shown in Figure 1.

In addition, suturing instrument **45** further includes a suturing head **70** which includes a separate tissue grasping mechanism and a piercing mechanism,

exemplary configurations of which are further described hereinbelow with reference to Figures 4 and 5.

The function of suturing instrument **45** is distinguished from the function of the formerly described embodiment. Whereas the formerly described embodiment includes a puncturer assembly, shown as puncturer assembly **3** in Figure 1, which grasps the tissue to be sutured, punctures the tissue and passes the suture through the tissue all in one movement, with a crochet head thereafter simply engaging the suture, suturing head **70** of the present embodiment has a tissue grasping mechanism **51** which is designed and configured for grasping a tissue and for positioning a suture on a first side of the tissue grasped thereby. Suturing head **70** further includes a separate crochet head **61** which is designed and configured for piercing through the tissue from a second side thereof and engaging the suture following piercing, thereafter enabling drawing the suture through the tissue.

Thus, in contrast to the formerly described embodiment, suturing instrument **45** includes separate piercing and grasping elements, which enable piercing the tissue and carrying the suture through the tissue following piercing thereof.

Such a suturing head **70** configuration provides a significant advantage in that it is capable of suturing tissues with a wide range of thicknesses, as there is no puncturer of a specific length to limit the thickness of the tissue capable of being sutured.

Figures 4 and 5 illustrate a detailed view of one preferred configuration of suturing head **70**, illustrating in detail the construction of tissue grasping mechanism **51**, hereinafter referred to as mechanism **51**, and crochet head **61**.

Mechanism **51** includes a static grasping member, hereinafter referred to as static member **52**, and a movable grasping member, hereinafter referred to as movable member **55**, both positioned at the distal end of suturing instrument **45.**

Static member **52** is disposed rigidly on an elongated shank which is similar to shank **21** illustrated in Figure 1. Movable member **55** is pivotally mounted to static member **52** by a pin, hereinafter referred to as pivot pin **56**, passing through holes formed in both static member **52** and movable member **55** aligned coaxially. The holes in static member **52** and movable member **55** are sized such that pivot pin **56** is affixed by friction within the hole through static member **52** but is movable relative to the hole through movable member **55**, allowing movable member **55** to rotate thereupon. Accordingly, movable member **55** is pivotally movable relative to static member **52**.

As described above, mechanism **51** is designed and configured for grasping and holding a tissue to be sutured. Accordingly, static member **52** and movable member **55** each have a face disposed substantially opposite one another. The face of static member **52** which faces movable member **55** is formed with a series of parallel grooves therein and is hereinafter referred to as ribbed surface **53**. Each groove of ribbed surface **53** is shaped and angled such that any tissue in contact therewith will be limited, preferably prevented, from moving with respect to static member **52**.

The pivotal movement of movable member **55** serves to move the face of movable member **55** both closer to, and farther from, ribbed surface **53**. The movement of movable member **55** is controlled by the movement of the second handle and a coupling rod, which are similar in function to handle **30** and coupling rod **35** described hereinabove with respect to Figure 1. Accordingly, the pivotal motion of handle (**30**), transmitted by coupling rod (**35**), will cause movable member **55** to pivot with respect to static member **52** in a jawlike manner, the closing motion being for grasping the tissue to be sutured, the opening motion being for releasing the tissue. Figure 4 depicts grasping mechanism **51** in a closed position. Figure 5 depicts grasping mechanism **51** in an open position.

Mechanism **51** is also designed and configured for positioning a suture on a first side of a tissue to be sutured. Reference is now made to Figure 6 which shows a detailed view of the distal end of movable member **55**. According to the alternative embodiment, movable member **55** has a distal end positioned substantially perpendicular to the face opposite static member **52** in the direction of static member **52**. This angular end of movable member **55** is hereinafter referred to as suture end **57**. Suture end **57** is preferably square or rectangular in shape, although it is appreciated that suture end **57** may be of any shape appropriate for the relevant tissue to be sutured.

Suture end **57** is formed with a groove along its circumference, or a portion of its circumference, hereinafter referred to as suture groove **58**. Suture groove **58** is sized so as to accept an appropriate suturing material. Accordingly, the previously described closing motion of movable member **55** serves to position a suture disposed within suture groove **58** on a (first) side of a tissue grasped by mechanism **51**.

Suture end **57** is also formed with an opening therein, hereinafter opening **59**, that is sized to allow crochet head **61** to pass therethrough. Opening **59** is shaped and positioned within suture end **57** such that one of its sides extends toward the circumference of suture end **57** beyond the depth of suture groove **58**. Accordingly, at the location that opening **59** approaches the circumference of suture end **57**, suture groove **58** is exposed to the inside of opening **59** such that a suture disposed therein is accessible from within opening **59**.

Suturing head **70** further includes crochet head **61**, designed and configured for piercing through a tissue grasped by mechanism **51**, engaging the suture and drawing the suture through the tissue. Crochet head **61** is part of a crochet head assembly **60** which also includes a third handle and coupling slide (similar to coupling slide **43** shown in Figure 1), The movement of coupling slide **43** and crochet head **61** is controlled by the movement of the

third handle, which is similar in function to handle **40** described hereinabove with respect to Figure 1.

Crochet head **61** is formed with a sharp point for piercing a tissue to be sutured, hereinafter referred to as point **62**, and a hooklike formation, hereinafter referred to as hook **63**, designed to deflect a suture as crochet head **61** first passes the suture when moving in the direction of its extended position and to engage the suture as it subsequently passes the suture moving in a reverse direction toward its retracted position.

Crochet head **61** is carried at the distal end of coupling slide **43**. Coupling slide **43**, which includes an element slidable with respect to elongated shank **21**, is coupled to the upper end of handle (**40**). Handle (**40**) is pivotally mounted to the first handle, which is similar in function to handle **20** described hereinabove with respect to Figure 1. Handle (**20**) is preferably spring biased (spring not shown) to return handle (**40**) to the position whereby crochet head **61** is in its retracted position. The movement of crochet head **61** is controlled by the movement of handle (**40**) and coupling slide **43** in substantially the same manner as previously described with reference to Figure 1.

Accordingly, the pivotal motion of handle (**40**) with respect to handle (**20**) will cause crochet head **61** to move through forward and return strokes substantially parallel to the longitudinal axis of elongated shank (**21**). Crochet head **61** is slidably mounted in proximity to mechanism **51** and is movable through a forward stroke from a retracted position at the proximal end of mechanism **51** to an extended position beyond suture end **57**, and through a return stroke back to the retracted position. The forward stroke of crochet head **61** is for piercing the tissue held by mechanism **51** and the return stroke of crochet head **61** is for engaging the suture and drawing it through the tissue.

The forward and return movements of crochet head **61** are guided by an inverted U-shaped guide member (similar to member **24** of Figure 1) which is formed as part of static member **52**. Guide member **24** guides point **62** to pass

within opening **59** at a point where opening **59** approaches the circumference of suture end **57** beyond the depth of suture groove **58** such that crochet head **61** passes between the circumference of opening **59** and a suture disposed within suture groove **58**.As described above, the deployment of handles (**20**, **30** and **40**) proximal to one another allows suturing instrument **45** to be easily employed by a user. Once the suture is disposed on suture head **70**, a user may preferably operate each of the handles in proper sequence by the fingers of one hand, as follows.

First, a suture is disposed within suture groove **58**. Thereafter, suturing instrument **45** is preferably held with the middle finger in the loop of handle (**20**), the index finger in the loop of handle (**40**) and the thumb in the loop of handle (**30**). The distal end of suturing instrument **45** is passed through a cannula and is placed at the surgical site. Handle (**30**) is pivoted away from handle (**20**) by the thumb so as to pivot movable member **55** such that grasping mechanism **51** is in its open position, as shown in Figure 5, to enable grasping mechanism **51** to grasp a tissue to be sutured. With grasping mechanism **51** in the open orientation, the instrument is positioned such that a tissue to be sutured is placed within the gap between static member **52** and movable member **55**.

Handle (**30**) is then pivoted towards handle (**20**) to pivot movable member **55** toward ribbed surface **53** causing mechanism **51** to move to its closed position (as shown in Figure 4) in order to both grasp the tissue and position the suture on the side of the tissue. Closing mechanism **51** causes opening **59** to align with guide member (**24**). Handle (**40**) is then pivoted toward handle (**20**) with the index finger to move crochet head **61** through a forward stroke from its retracted position at the proximal end of mechanism **51** to beyond suture end **57**. Handle (**40**) is then released to permit its spring bias to return crochet head **61** through a return stroke back to its retracted position at the proximal end of mechanism **51**. If necessary, the index finger in the loop of

handle (**40**) could forcibly pivot handle (**40**) away from handle (**20**) causing crochet head **61** to return to its retracted position.

During the movement of crochet head **61** in the forward stroke, point **62** pierces and penetrates through the tissue grasped and thereafter passes between the suture within suture groove **58** and the circumference of opening **59**. Crochet head **61** is thus moved sufficiently past the suture such that hook **63** engages the suture on the return stroke and draws it through the hole pierced through the tissue. Handle (**30**) is then pivoted away from handle (**20**) by the thumb to move mechanism **51** to its open position, and thereby to release the tissue. Thereafter, suturing instrument **45** may then be withdrawn from the cannula, drawing the suture with it.

The suturing instruments of the present invention offer a number of substantial advantages over previously described suturing devices. The first advantage is simplicity of construction. Both embodiments of the suturing instrument are of simple mechanical design and are fabricated from a relatively small number of moving parts. In addition, the suturing instruments of the present invention do not depend upon excessively close tolerances to function effectively.

Furthermore, the suturing instruments of the present invention may be employed with one hand; once the suture is deployed on the device, the tissue may be grasped and the suture completed solely by the movement of the fingers of one hand, leaving the other hand free.

Finally, the suturing instruments of the present invention provide a positive and reliable method of effecting a suture from a remote location, thus avoiding missed stitches, a limitation which plagues devices employing separate piercing and retracting elements.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided

in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable subcombination.

Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims. All publications, patents and patent applications mentioned in this specification are herein incorporated in their entirety by reference into the specification, to the same extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated herein by reference. In addition, citation or identification of any reference in this application shall not be construed as an admission that such reference is available as prior art to the present invention.